Effect of resin primer solvents and surface wetness on resin composite bond strength to dentin

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Abstract: This study investigated the effect of various solvents on resin composite bond strength to dentin with both wet and dry dentin. A generic dentin bonding system was created with HEMA as the resin in the primer. The highest bond strengths were obtained when acetone was used as the solvent on a wet dentin surface; the lowest bond strengths were obtained with water as the solvent and the primer placed on a wet dentin surface. (*Am J Dent* 1992; 5: 213-215).

Clinical significance: Certain types of primer solvents can affect the clinical behavior of resin adhesives. Although further research is indicated, it appears that primers containing acetone may function best on the dentin surface *in vivo*, which is normally moist.

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Introduction

It has generally been assumed that the presence of moisture is deleterious to the adhesion of bonding resins to dentin. Systems that simulate the physiologic state of dentin have supported that position. Terkla *et al*[1] noted that resin bonding systems did not seal dentin when the dentin was moist. Mitchem *et al*,[2] Andreaus *et al*[3] and Tao & Pashley[4] reported that bond strengths of various dentin bonding systems were diminished in the presence of simulated pulpal pressure. Glasspoole *et al*[5] reported that the bond strength of Scotchbond 2[a] is diminished in the presence of small amounts of moisture. Tao *et al*[6] reported that under simulated physiologic pulpal pressure, the bond strength of Gluma[b] was diminished by 50% but the bond strength of Superbond[c] was unaffected. Contrary to these, Kanca[7] reported that the bond strength of the All Bond[d] dentin-enamel bonding system to dentin was enhanced by the presence of moisture.

Unpublished observations suggested that the primer solvent may have an effect on the ability of a resin to generate adhesion to both moist and dry dentin surfaces.

The purpose of this paper was to investigate the bond strengths to dentin that are obtained with a generic dentin bonding system varying both the primer solvents and wetness of the dentin surface.

Materials and Methods

Sixty extracted human molars free of obvious defects and within 2 weeks of harvest, were selected for this study. They were stored in tap water at 4°C. For the experiment, the teeth were embedded in an autopolymerizing acrylic in a stainless ring with an inside diameter of 1 inch. The teeth were ground on a model trimmer to expose adequate dentin surface for bonding. The exposed dentin surfaces were wet-sanded with 320 grit sandpaper and the teeth were left in water for 24 hours at 4°C to hydrate the teeth. Following storage, the teeth were warmed to body temperature for the experimental procedure by placement in 37°C water for 30 minutes.

Three solvents were examined; water, 90% ethanol and acetone. Hydroxyethylmethacrylate (HEMA), was mixed into each solvent so as to create a 20% HEMA/solvent ratio. The selection of the 20% figure was arbitrary but it is in the range of typical resin primers. HEMA was selected as it is a commonly used resin for dentin primers and because HEMA is soluble in all three of the solvents. The three primers thus consisted of: 20% HEMA/water, 20% HEMA/ethanol and 20% HEMA/acetone. There were three different treatment groups:

Group 1 - The dentin was treated with a 10% phosphoric acid gel etchant (All Etch[d]) for 30 seconds and rinsed for 10 seconds. After rinsing, the dentin was air-dried for 5 seconds with oil-free dry compressed air with the tip of the syringe approximately 2-3 cm from the dentin surface. Four coats of the 20% HEMA/water were applied to the dentin and allowed to remain undisturbed for 10 seconds. The surface was then air-dried for 10 seconds. A thin layer of Bisco Dentin-Enamel[d] unfilled bonding resin was then applied to the primed dentin surface. It was not air-thinned. The layer of unfilled resin was then light-polymerized for 20 seconds (Demetron 401[e]). A teflon mold 2.5 mm in thickness, having a cylindrical matrix of 4 mm diameter was then clamped to the embedded tooth such that the matrix was over the treated dentin. The matrix was filled with a single increment of BisFil[d] composite (Universal shade) and light-activated for 40 seconds.

A second group of 10 teeth was treated as above except that following etching and rinsing of the dentin, the dentin surface was wiped with a wet facial tissue to remove the excess water only. The surface of the dentin remained visibly moist (*i.e.* the surface was shiny as opposed to matte).

Group 2 - The teeth were treated as in Group 1, except that the primer/solvent was 20% HEMA/ethanol. Ten were air-dried following etching and rinsing and 10 were left moist.

Group 3 - The teeth in this group were treated similarly to Group 1 except that the primer/solvent was 20% HEMA/

Table 1. Bond strengths obtained with different solvents and dentin surface dryness conditions (MPa).

Resin/solvent	Dentin surface Wet - MPa (S.D.)	Dry - MPa (S.D.)
1. HEMA/water	0	5.7 (3.1)
2. HEMA/ethanol	16.2 (5.5)	5.4 (2.4)
3. HEMA/acetone	22.4 (2.8)	6.4 (2.7)

acetone. Ten of the teeth were air-dried following etching and rinsing and ten were left moist.

The matrices were removed from the teeth and the samples were stored for 24 hours in water at 37°C. Shear bond strength was measured on an Instron machine[f] (Model 1123) with a crosshead speed of 5 mm/minute and recorded. A sharp blade was used to shear the samples with the blade parallel and immediately adjacent to the bonded dentin surface.

Results

The results are listed in Table 1. The air-dried samples in Group 1 had a mean shear bond strength of 5.7 MPa (±3.1). The moist-surface samples in Group 1 all failed spontaneously prior to beginning the shear testing. The air-dried samples in Group 2 had a mean shear bond strength of 5.4 MPa (±2.4). The moist surface samples in Group 2 had a mean shear bond strength of 16.25 MPa (±5.5) The air-dried samples in Group 3 had a mean shear bond strength of 6.4 MPa (±2.7). The moist surface samples in Group 3 had a mean shear bond strength of 22.4 MPa (±2.8). The highest bond strength values were obtained with the HEMA/acetone primer on a wet dentin surface. The lowest bond strengths were obtained when HEMA/water was the primer on a wet dentin surface. HEMA/alcohol on a wet dentin surface resulted in higher bond strengths than HEMA/alcohol on a dry dentin surface.

Discussion

For purposes of perspective, it is noted that typical shear bond strength values obtained by the author for 37% etched enamel are in the range of 28-30 MPa. Any discussion of dentin bond strength values should include an etched enamel value. It need not be included in the materials and methods, but it does provide a standard with which to compare or contrast. Each researcher is likely to experience a fairly consistent value in his/her laboratory for 37% etched enamel. This number will help other researchers place into perspective the values being reported. Without this standard value results are difficult to interpret.

The data generated indicate that there are interactions occurring between the resin solvent and the dentin surface. These interactions appear to be dependent on both the individual solvent and the presence of surface moisture. It is a common practice to use acetone as a drying agent on glassware. When acetone is mixed with water, the vapor pressure of water is elevated.[8] This will cause some of the surface water to be volatilized. In addition to the change in vapor pressure, the addition of acetone to water decreases the surface tension of water.[8] This has the effect of causing the acetone to appear to "chase" the water. This will continue until an equilibrium is established. Since the resin HEMA is present in the acetone in this experiment, the resin is thus carried with acetone as it chases the water. It apparently is deposited intimately onto and into the dentinal substrate, probably both the surface and the tubules, and increased adhesion is effected through better wetting of the surface.

When the dentin surface is dried, there is no water to chase and the wetting of the surface is diminished. Alcohol behaves similarly to acetone. The addition of alcohol to water decreases the surface tension of water,[8] yet the bond strengths generated were not as high as with the acetone solvent. This is evidently a consequence of alcohol having greater hydrogen bonding than acetone and thus it does not chase water as effectively. Again, when the surface is dry, there is no interaction of the solvent with water and the adhesion is diminished.

When water is used as the solvent, it will not reduce its own surface tension nor is there any change in the vapor pressure. Thus it is not expected that the HEMA/water mixture would chase the water present on the surface. It was predicted that the HEMA/water mixture would function best when the surface was dried, and this is what occurred.

Dentin tubules of vital teeth are filled with fluid and this fluid is under pressure. Brannstrom[9] has reported that the flow of this fluid is sufficient to empty the tubules 10 times per day. Since dentin is inherently a wet surface, the data presented here pose some serious implications. Since dentin is difficult to dry clinically (and probably impossible *in vivo*) it is likely that bonding systems containing solvents capable of beneficial interactions with water will be the most successful. The implication is also that dentin bonding systems utilizing water as the resin solvent will probably be less effective in all but superficial dentin.

Conclusions

1. The moisture content of dentin surfaces can have a significant effect on adhesion.
2. The solvent in which the primer resin is carried can have a significant effect on dentin adhesion.
3. Interaction of the primer solvent with surface moisture can result in better wetting of the dentin surface by the primer.
4. Acetone appears to be the most successful solvent on a wet dentin surface.
5. The most successful dentin bonding systems will be those that are able to function in the presence of moisture.

a. 3M Dental Products, Minneapolis, MN, USA.
b. Miles Inc., South Bend, IN, USA.
c. Sun Medical Co., Kyoto, Japan/Parkell, NY, USA.
d. Bisco Dental Products, Itasca, IL, USA.
e. Demetron Inc., Danbury, CT, USA.
f. Instron, Canton, MA, USA.

Acknowledgement: To Dr. Mike Bradley, University of Connecticut, USA,

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CE Questions - Effect of resin primer solvents and surface wetness on resin composite bond strength to dentin.

1. **Interactions between the resin solvent and the dentin surface:**
   A. Are affected by temperature
   B. Are not affected by temperature
   C. Depend on the solvent and the presence of moisture
   D. Depend on the drying properties of alcohol
   E. None of the above
2. **Dentin adhesion was best with:**
   A. Acetone
   B. Water only
   C. Dried dentin surface
   D. Alcohol
   E. None of the above

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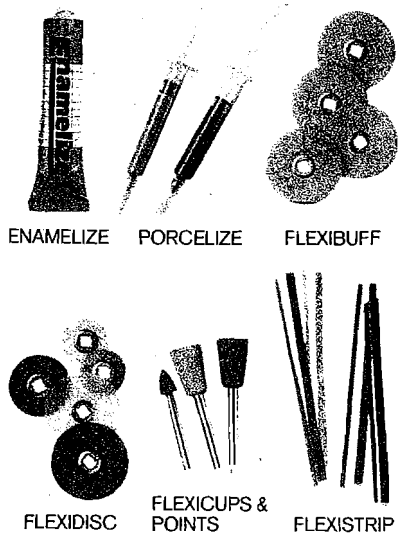

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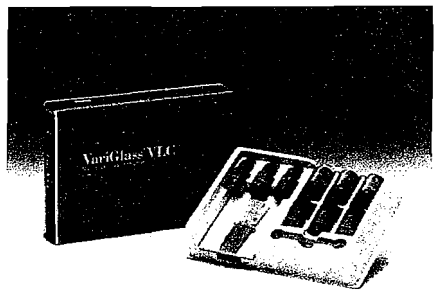

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